Conference Report

1st French Plenary Meeting on Gold Nanoparticles in Physics, Chemistry and Biology
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A meeting on Gold Nanoparticles took place on November 27 and 28, 2006 in Paris. This was the first official meeting taking place within the framework of the so-called Groupement de Recherche, entitled GDR Or-nano (for Gold Nanoparticles). It has been created by the CNRS[1] in 2006 for 4 years, under the direction of Dr Catherine Louis.[2]

This meeting gathered around 130 French researchers (as well as 3 Belgians and 1 Swiss) working on Gold Nanoparticles in different fields: physics, chemistry and biology. The goal of this meeting was to establish the state of art in France on this topic and to generate new collaborations (the program, abstracts and some oral presentations can be found at www.or-nano.org). The meeting is in fact the follow-up of a former non-official pre-meeting held in June 2005 in Paris. A report had been published in CatGoldNews (no. 6, 2006).

I Gold Nanoparticle synthesis

Original methods are developed in France to produce gold nanoparticles: sonolysis[3], radiolysis[4] and dendrimeric[5] chemistry. These methods of synthesis in liquid phase are very attractive for chemists, physicists and biologists because they allow the control of gold particle size and morphology. They can also lead to the synthesis of bimetallic particles, which is another challenge since the latter can combine the effect of the two elements or induce synergetic effects, useful for instance for catalysis.

II Catalytic reactivity

During the session on heterogeneous catalysis by gold, a number of topics were raised:

- The very popular CO oxidation is still attracting many studies, for instance in excess of hydrogen for the purification of hydrogen for fuel cell.[6] The reaction of selective hydrogenation of 1,3 butadiene is also a reaction studied by several groups on real and model catalysts. Michèle Besson[7] presented a very interesting overview on the liquid phase oxidation with heterogeneous gold catalysts;
- The need to investigate changes of morphology of gold nanoparticles under reaction conditions.

Several oral presentations and posters showed that sophisticated physical techniques start to allow answering these questions. For instance, Suzanne Giorgio of CRMCN[8] presented results obtained with an environmental high-resolution electron microscopy (the third equipment in the world after those belonging to private American and Danish Companies), i.e., changes of gold particle morphology under hydrogen and oxygen atmospheres. Other techniques, such as GISAXS (Grazing Incident Small Angle X-ray Scattering),[9,10] performed at the ESRF European synchrotron, or SFG (Sum Frequency Generation)[11] provide information on particle morphology under gas, but more indirectly. Moreover, they

require model catalysts, i.e., flat oxide support surfaces.

Theoretical chemistry is another way of answering these questions, through modelisation of catalytic systems and optimisation of reaction pathways. The group of Françoise Delbecq and David Loffreda[12] starts working on this topic, and they presented us promising results on gold catalysts.

III Physical properties and characterisation

Jean Lermé[13] presented the physics that lies behind the plasmon resonance of gold nanoparticules, and gives rise to their very specific optical properties. He stressed how the size, morphology and nature of the substrate affect the physical properties, such as band structure, dielectric function and as a consequence, modify the optical properties of gold nanoparticles. Fabrice Vallée[13] showed that it is possible to observe a single gold nanoparticle, and to determine its optical properties and its behaviour under a femto-second laser excitation. These results open interesting perspective, for instance in catalysis for the study of the plasmon resonance of a single gold particle under reaction conditions.

Other presentations showed other original results. Photothermal and absorption correlation spectroscopies[14] are techniques used to observe one single gold particle. For instance for biological application, it is possible follow the motion of a neurotransmitter and so investigate the synaptic mechanisms taking place inside neurones. The plasmon resonance of gold nanoparticles can also be used to amplify or quench light emission coming from a close luminophore.[15] Gold nanoparticles can be heated by a laser beam and heat can be transmitted to the surrounding. Bruno Palpant[16] gives rise to both optical effects, linear and non-linear, and thermal effects. These effects interact with each other depending on the time scale under consideration (10^{-12} to 10^{-9} s). The thermal and optical properties of gold nanoparticles are especially interesting for colour, optical telecommunications, optical limitation, local thermal sensing, cancer therapy. It has been also shown during this meeting that gold nanoparticles assembled as a film can develop original optical properties and very intense local electric fields.[17]

IV Biology

In their conference, Gérard Morel[18] and by Cécile Sicard-Roselli[19] gathered different applications and uses of gold nanoparticles in biology (imaging by fluorescence, electrochemistry, drug vectorization, therapy), as well as specific needs of the biologists in terms of gold nanoparticles. The needs are numerous, and require collaboration between several fields of science:

- Synthesis of gold nanoparticles with well-controlled size and shape, adapted to *in vivo* conditions where important variations of pH and ionic strength can be encountered; they must be « clean», i.e., free of toxic precursor or stabilising agents; they must remain « soluble » in physiological conditions;
- Controlled grafting of bio-molecules on gold nanoparticles, such antibodies to target tumoral cells;
- More complex grafting of bio-molecules so as to lead to bifonctionalised gold nanoparticles able to vectorize, and then to release active principles;
- Characterisations of interaction between nanoparticles and biological molecules through spectroscopic methods, for instance XAFS, XPS, Raman or IR;
- Understanding of the mechanisms of hyperthermia and bubble formation in the tissues around gold nanoparticles when the latters are irradiated by X-ray; the presence of gold improves X-ray efficiency for cancer therapy.

Shorter talks have presented applications dealing with nanocomposites, protein biosensors and synthesis of hybride gold nanoparticles for imaging by magnetic resonance. Some biosensors can be prepared by electronic lithography. This allows to control size and shape of gold nanoparticles on a substrate. The change of the plasmon resonance detected by SNOM was used to get evidence of grafting of antigen/antibody couple (biotine/antibiotine) on gold nanoparticles.[20] This is the first step for the use of gold nanoparticles as biosensors for diagnostic/diagnosis. On the other hand, it was shown that biological medium can provide the formation of gold nanoparticles.[21] Micro-alguas "fed" by chloroauric acid are able to synthesize gold nanoparticles without alteration of their own biological functions, and to release them in the aqueous extra-cell medium. Moreover micro-alguas can be recycled. This is a new nice example of « green » chemistry.

V Conclusion and future

The complementarities of the fields of physics, chemistry and biology, and the requirement of more collaboration between these different fields clearly appears through the questions of synthesis, characterisation and uses of gold nanoparticles.

From the round table discussion at the end of the meeting, the following conclusions may be drawn :

- Even though it is not straightforward to always understand each others because of different language and scientific backgrounds, a certain number of contacts have already been established among the participants, and will probably lead to interdisciplinary collaboration.
- Attendants seem convinced by the advantage of such an interdisciplinary meeting.
- This type of meeting must be renewed, maybe focussing more specifically on a given topic interesting for the three fields.
- Maybe this type of meeting should be opened to the European community, but the problem of raising fund is opened.

References

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